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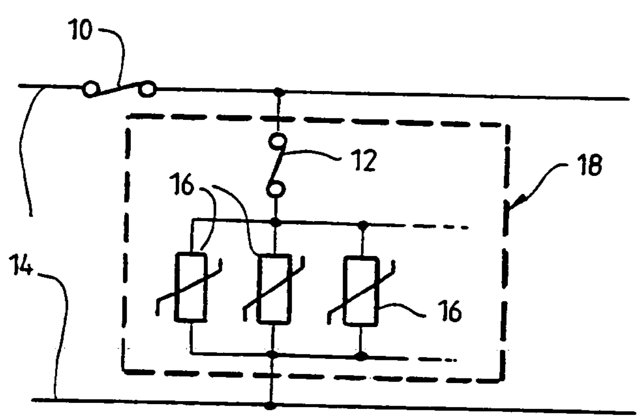


(57) Abstract

A protection arrangement for electricity distribution lines (14) includes a plurality of stacks (18) of metal oxide varistors MOVs (16), said stacks (18) being arranged in parallel. Each stack (18) is internally fused using a thin, wide strip of copper encapsulated in a flameproof material. An alarm (22) and status display (26) may be provided within a single module (32). Each MOV (16) may have an individual fuse (134). An alternative alarm system may be provided using an insulating mask applied over a fuse (134), over which a conductive ink (138) is applied, the ink (138) being connected to an alarm. Failure of an MOV (16) will physically rupture the ink (138) leading to an alarm being created.

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# IMPROVEMENTS IN SURGE DIVERTERS

This invention relates to improvements in surge diverters operating at distribution voltages, and in particular relates to clamping overvoltages resulting from occurrences such as lightning.

Existing technology in such matters involves the use of varistors made of metal oxide to clamp lightning–induced transients on power lines.

The metal oxide varistor (MOV) is a bipolar clamping device which becomes non–linear when a certain threshold voltage is applied. The MOV has excellent energy absorption ability but tends to degrade with each electrical impulse. This degradation is observed as a fusing of sectors of the internal crystalline structure, and leads to a lowering of the conduction threshold.

Excessive energy levels in an electrical transient or repetitive transients at a lower level cause overheating and the abovementioned degradation. The result is conduction on the peak values of the AC supply and thermal runaway leading to the device producing a short circuit. It is quite common for MOVs to explode.

Lightning flashes, which can be a cause of the excessive energy levels, may comprise several discharges consecutively using the conductive air channel. Thus, an MOV may be subject to rapid degradation as a result of a multiple strike event.

In order to overcome the dangers of a short circuit caused by MOV failure, two procedures are commonly applied. These are:

1. Rating the series line fuse such that MOV failure will cause operation. This action disconnects power from the protected equipment, but the fuse cannot be replaced and power restored until the faulty MOV is replaced. Such an arrangement is shown in Fig. 1.
2. Providing a protective fuse 10 in series with the MOV, which is of lesser rating than the line fuse 12. This allows MOV disconnection without equipment supply loss due to operation of the line fuse. This arrangement is shown in Fig. 2.

In selecting the value of fuses, several parameters must be considered. These are:

1. The line fuse must always have greater 50Hz ratings than the MOV fuse or a failed MOV will repeatedly take out the line fuse.
2. The line fuse has an impulse limit based on its $I^2t$ reaction time.
3. The MOV fuse should have a lower impulse rating than a line fuse, to

ensure MOV disconnection does not occur before line fuse operation.

It is an object of this invention to provide an improved surge diverter.

The invention provides a protection system for distribution lines, including at least two individually fused stacks of metal oxide varistors arranged in parallel, such that failure due to deterioration within one of said stacks will cause that stack only to disconnect without operation of a designated series line fuse.

The invention also provides a fuse arrangement for a distribution line protection system, a fuse element comprising a wide, thin strip of copper having low resistance to AC current, said strip being encapsulated in flameproof material, such that it will carry an impulse current equivalent to a conventional cylindrical fuse of from two to three times the area of copper, thus permitting disconnection as defined in claim 1, of stacks, while maintaining overvoltage protection integrity for impulse levels which may be in excess of the capacity of a line fuse.

The invention further provides a protection system for distribution lines, in which at least two parallel stacks of metal oxide varistors are provided, a monitoring arrangement which monitors the integrity of a stack fuse, and displays the status thereof on a progressively reducing bar graph, irrespective of the order of failure of stacks.

The invention also provides a protection system for distribution lines, the provision of clean contacts for transmission of a status alarm to a remote point upon the failure of a predetermined number of internal stack fuses forming part of said protection system.

The invention further provides a protection system for distribution lines, in which a multiplicity of paths is provided, said paths leading to overvoltage clamping devices which receive a lower 'per device' current, and produce a lower voltage due to dI/dt in each conductor.

The invention also provides a lightning protection arrangement for electricity distribution lines, including a plurality of groups of protection devices, each of said protection devices being a metal oxide varistor (MOV), each of said groups of protection devices including a plurality of protection devices arranged in parallel, each of said groups being located in parallel, said arrangement operating such that upon failure of a protection device in one of said groups, reduced protection will be provided by the remaining group or groups in the arrangement.

The invention further provides an alarm system for indicating the failure of a protection device for electricity distribution lines, including an insulating mask applied to

an area in the vicinity of said protection device, and a conductive ink laid over said mask, said ink being connected into an alarm system, such that failure of the protection device physically breaks said conductive ink, resulting in an open circuit.

Embodiments of the invention, which may be preferred, will be described in detail hereinafter with reference to the accompanying drawings, in which:–

Fig. 1 is a circuit diagram of one prior art fuse arrangement;

Fig. 2 is a circuit diagram of another prior art fuse arrangement;

Fig. 3 is a circuit diagram of a first embodiment of the invention;

Fig. 4 is a circuit diagram showing a number of the circuit elements of Fig. 3;

Fig. 5 is a circuit diagram of a failure alarm system;

Fig. 6 is a circuit diagram showing the provision of power to the circuit of Fig. 5;

Fig. 7 is a circuit diagram showing how the third connection of Fig. 6 is used to power the alarm;

Fig. 8 is a diagrammatic side elevation of a lightning protection arrangement according to the invention;

Fig. 9 is a view similar to that of Fig. 8, showing a prior art arrangement;

Fig. 10 is a circuit diagram similar to that of Fig. 3, with individual MOV fusing; and

Fig. 11 is a circuit diagram showing an arrangement for providing an alarm.

In prior art Fig. 1, the line 14 has an MOV 16 connected thereto. A series line fuse 10 is also provided.

Prior art Fig. 2 has an additional line fuse 12 which has a greater rating than line fuse 10.

Referring now to Fig. 3, which is basically similar to Fig. 2, a number of MOVs 16 is connected in parallel to form a MOV 'stack' 18. Preferably the MOVs are of relatively small diameter. Individual MOVs in each stack are internally fused in a particular manner.

In Fig. 4, MOV stacks 18 are themselves arranged in a parallel situation. This arrangement of placing in parallel individually fused stacks of MOVs allows failure and consequent disconnection of any one MOV device 18 without danger of line fuse operation. If it is assumed that the MOV fuse is of conventional format, the fuse rating may be I/N of that of the line fuse, where N is the number of MOV devices 18 in parallel. This is a conventional engineering concept.

Conventional fuses are in the form of a conducting wire. The circular format of wire presents the maximum cross section for the minimum surface area. When skin effect is taken into account, this geometry produces a high A.C. resistance to rapidly changing currents such as those experienced with lightning.

It has been discovered that the AC resistance for a given cross section of a fuse is reduced by utilising wide copper strip such as that on a printed circuit board. However, this alone does not markedly improve performance as it was discovered that the copper would delaminate from the PCB and stretch due to both heat and mechanical stress.

Thus, the optimum is joint utilisation of the conductive strip format and use of a solid flameproof encapsulant to prevent stretching and delamination. The net result is that within certain limits such a fuse arrangement can carry approximately three times the impulse current of a cylindrical conductor for the same cross section of conductor. It is also a feature of the invention that this advantage can be controlled by selecting the hardness of the encapsulant.

At power frequencies, skin effect if not an effect to be considered. The cross-sectional area of conductor is the predominant parameter for fusing. The discovery of the present invention can be applied to the invention to allow parallelling of MOV stacks 18 in such a manner that the impulse performance, and power frequency fusing performance, can be controlled to achieve desired parameters.

The present invention makes it possible to have a line fuse of a given copper cross section and a MOV device fuse of lesser cross section. Thus, the MOV fuse can be designed to carry a higher pulse current than the line fuse without rupture, yet, on short circuiting of the MOV 16, the fuse will rupture prior to the line fuse. A typical system according to Fig. 2, would have line fuse 10 rated at, say, 63 Amp. This fuse would maintain integrity on a 20kA, 8/20 microsecond impulse. The MOV fuses 12 can each be rated for 5kA on impulse, providing a total pulse capacity of 25kA for a sector while each individual MOV would have a rupture rating of only 10 Amperes at 50Hz. Failing MOVs would be progressively isolated without affecting the integrity of the equipment power supply.

Arrangements can be extended in this manner where very high single impulses can be absorbed over many parallelled devices without MOV fuse rupture. Conversely, after repetitive impulses of a lesser level leading to failure of a MOV within a stack 18, that device 18 will be disconnected without interruption of the equipment power supply.

It is a principle of lightning protection that equipment integrity must be maintained as a priority over power supply failure. In this invention, a lightning pulse in excess of the line fuse rating will cause its rupture while the MOV fuse integrity is maintained to limit overvoltages reaching equipment. However, on MOV degradation MOV devices will be isolated on failure without operation of the line fuse.

In the knowledge that MOVs have a finite life, it has been past practice to provide status alarms. These generally are fuses or fusible links which operate to the MOV substrate temperature. Mechanical or electronic flagging of the failure is provided. In all cases, device failure removes protection from the circuit.

It is an additional feature of this invention that the multiple devices 18 may fail individually and in any order, while protection continues to be provided by the remaining MOV devices. A single impulse of excess capacity may drive the weakest MOV into the short circuit mode, where, in failing it provides inherent protection to the balance of the residual stacks. It may be said that the invention has built–in redundancy.

A further feature is that stack failure can be flagged by an alarm system providing a residual capacity indication. For example, a typical system could comprise five stacks with a five–segment bar graph to indicate residual capacity. The invention provides for the use of opto isolators 24 and adding circuits (Fig. 5) to produce a progressive reduction in illuminated LEDs 26 on a bar graph, irrespective of the order of failure of devices in the various stacks.

The sensing of the integrity of the MOV fuse of Fig. 5 is conveyed to the alarm panel 22 via a series of opto isolators 24. There is only a single reference connection between the MOV stacks 18 and the alarm system.

All of the elements enclosed within the broken line in Fig. 5, including the clean contacts 28, are located in a common module with an integral alarm system.

In Fig. 6, a third connection 30 is shown. Connection 30 provides power to alarm system 22. Reference connection 38 is also shown.

Fig. 7 shows how connection 30 is utilised to provide alarm system 22, (in each of modules 32,34,36) with power, without danger of earth leakage, irrespective of whether the system is connected Active–Neutral Active–Earth or Neutral–Earth.

In the marketplace, the product would be housed in a common container with integral fuses together with visual and electrical alarm indicators.

Referring now to Fig. 8 and 9, one exemplary clamping voltage for lightning–

induced transients is 275V, which would be for systems operating on 220v–240v AC supplies. The system will work equally well with lower–voltage MOVs for 110v–120v AC supplies.

In designating protection of power circuits using MOV's two unknowns are exhibited. The first is the level of energy to be absorbed. Lightning discharges typically vary from 3 kA to 300 kA peak current, with average strokes centering near the 30kA value.

Secondly, a lightning flash may comprise several discharges consecutively using the conductive air channel. These repetitive strokes may occur at 15 to 150 millisecond intervals and each will exist for several hundred microseconds.

Currently, MOV manufacturers specify a single shot peak current which the device is able to withstand. Additionally, data is available on how many single shot discharges may be absorbed at a lesser peak current. This data is based on there being adequate cooling time between each discharge.

MOV's are currently available in disc form with diameters smaller than 5mm through to large capacity 80mm or greater devices rated for a 100kA single shot impulse.

Recent tests show that these devices when subjected to repetitive strokes as occur in nature, will exhibit hot spots across the substrate. This is due to inhomogeneity in the oxide mixing process occurring during manufacture.

It is these hot spots that ultimately cause device failure, which takes the form of a short circuit. It is common for failed MOV's to explode due to the power follow–on current through the short circuit. Even though it is common practice to use a series fuse to disconnect a failed device from the line it was protecting, the thermal delay may allow 15 to 20 cycles of very high current to pass into the device. Mechanical destruction can still occur in these instances.

In the arrangement 110 of Fig. 8, groups 112,114,116 of MOV's in parallel, are arranged between two conductive plates 118, 120.

One conductive plate (118) is grounded or connected to low voltage electrode 122. The other conductive plate (120) is connected to the line 124 to be protected.

The groups of MOV's are preferably radially located between plates 118, 120, but may also be connected via flat conductive plates to reduce inductive effects. Although three MOV's are shown in each of groups 112,114,116, a more typical number per group is believed to be five. Each group is individually fused by respective fuses or circuit

breakers 126,128,130, at a suitable rating to conduct lightning–type surges, but of value to operate should one of the MOV's fail into a short circuit mode.

In the arrangement of Fig. 8, an overstressed MOV in a section or group such as 114,116 or 118 will fail in the short circuit mode. In so doing, it will protect all other MOV's until after a time lag, its fuse (126,128,130) will operate and disconnect it from circuit.

In the case of a single large MOV, the whole device would fail and the circuit be left without protection, even though the thunderstorm which caused the initial surge could still be raging. This invention allows the failure of a device due to an exceptionally high impulse or a multi stroke event. The mode of failure is such that the failing device protects the remaining sections or groups, which maintain their integrity after the event.

Typically, some 80% of protection would remain and prove quite adequate to cater for any but the exceptional events.

In the arrangement of Fig. 8, a series of signal wires may be brought out of the device at points A,B and C. The failure of a sector can be signalled by lamp or audible alarm (not shown). Each group or sector, if there are, for example, five in number, would represent 20% of the rated capacity of the device. This allows the progressive failure to be indicated as 80,60,40,20,0%.

The advantages of the Fig. 8 arrangement over a single block device are several. Failure of a single block device represents total failure of the protective system. No redundancy is offered to maintain a lesser degree of protection.

The individual fusing of devices means that each fuse may be of lesser value than needed for a single block MOV. In the latter case, the MOV protective fuse may need to be larger than the rating of the supply circuit breaker. For example, a hilltop radio site may only require a 63 Amp circuit but high level protection is called up. This may require a 100 Amp protective fuse in the MOV circuit (Fig. 9). The result will be power supply interruption on MOV failure, and the line fuse would rupture before the MOV fuse. This would not occur on a segmented system, such as that shown in Fig. 8. The overall impulse rating is set by the 63A line fuse, but individual MOVs will disconnect on failure, without line fuse operation.

In Fig. 8, each section (112,114,116) may have a 20A fuse or the like (126,128,130 respectively).

The MOV's in Fig. 8 may each by typically rated from 1kA to 10kA. Preferably,

each MOV is a 6.5kA 20mm diameter MOV. Preferably, there are 5 or 6 MOV's in each group or sector.

Fig. 10 shows an arrangement 132, similar to that of Fig. 3, where the stack fuse 12 is replaced by individual fuses 134, preferably each of a significantly lesser value than a fuse such as 12 of Fig. 3.

Such an arrangement reduces the energy absorbed by a MOV in failure mode, reduces the heat to be absorbed and further reduces the risk of mechanical explosion.

When the previously mentioned stack fuse 12 (Fig. 3) is used, it is easy to detect failure. Failure exhibited by removal of power to the entire sector. However, when, say, 5 individual fuses 134 are used in each stack, it is more difficult to detect failure of one without a significant increase in monitoring circuit componentry.

Fig. 11 is a more detailed view of a modification 136 of the type of arrangement shown in Fig. 10, designed to overcome the aforementioned problem.

MOVs 16 are arranged much as shown in Fig. 10, with individual fuses 134. Preferably, the arrangement 136 uses a printed circuit board with fuses 134 overlaid with a solder mask (preferably a hard epoxy film with good insulation properties) for electrical insulation, and further overlaid with a conductive ink 138. Preferably, the conductive ink 138 also has an epoxy base.

The conductive ink 138 is preferably connected into an alarm circuit (not shown) or the like.

Any fuse failure in the five-MOV stack shown in Fig. 11 will burn the ink 138 and cause it to open circuit. This disconnects the power to the stack alarm. A stack alarm is thus given for any MOV failure within the stack. This arrangement is particularly suitable when line fuses to protected equipment are of relatively low value, as individual MOV fuses can be rated for the appropriate impulse level but have a lower 50Hz rupture capacity. This will allow faulty MOV disconnection without fear of line fuse operation.

Thus, the arrangement of Fig. 11 provides a low-cost alarm system for a surge diverter.

CLAIMS

1. A protection system for distribution lines, including at least two individually fused stacks of metal oxide varistors arranged in parallel, such that failure due to deterioration within one of said stacks will cause that stack only to disconnect without operation of a designated series line fuse.

2. A protection system according to claim 1, wherein each of said stacks has an impulse current rating in excess of said line fuse.

3. In a fuse arrangement for a distribution line protection system, a fuse element comprising a wide, thin strip of copper having low resistance to AC current, said strip being encapsulated in flameproof material, such that it will carry an impulse current equivalent to a conventional cylindrical fuse of from two to three times the area of copper, thus permitting disconnection as defined in claim 1, of stacks, while maintaining overvoltage protection integrity for impulse levels which may be in excess of the capacity of a line fuse.

4. In a protection system for distribution lines, in which at least two parallel stacks of metal oxide varistors are provided, a monitoring arrangement which monitors the integrity of a stack fuse, and displays the status thereof on a progressively reducing bar graph, irrespective of the order of failure of stacks.

5. A monitoring arrangement according to claim 4, wherein said bar graph is constituted by LEDs.

6. In a protection system for distribution lines, the provision of clean contacts for transmission of a status alarm to a remote point upon the failure of a predetermined number of internal stack fuses forming part of said protection system.

7. A protection system for distribution lines, in which a multiplicity of paths is provided, said paths leading to overvoltage clamping devices which receive a lower 'per device' current, and produce a lower voltage due to dI/dt in each conductor.

8. A system according to claim 7, wherein said devices are MOVs and in which the paths are provided by arranging the MOVs in parallel stacks.

9. A lightning protection arrangement for electricity distribution lines, including a plurality of groups of protection devices, each of said protection devices being a metal oxide varistor (MOV), each of said groups of protection devices including a plurality of protection devices arranged in parallel, each of said groups being located in parallel, said arrangement operating such that upon failure of a protection device in one of said groups,

reduced protection will be provided by the remaining group or groups in the arrangement.

10. An arrangement according to claim 9, wherein said groups are located between and connected to, two conductive plates, one of said conductive plates being connected to the line to be protected, and each connection between one of said groups and a plate is provided with a fuse or circuit breaker.

11. An arrangement according to claim 9 or claim 10, further including a lamp or audible alarm which is adapted to operate when a group fails due to the failure of a protection device in that group.

12. An alarm system for indicating the failure of a protection device for electricity distribution lines, including an insulating mask applied to an area in the vicinity of said protection device, and a conductive ink laid over said mask, said ink being connected into an alarm system, such that failure of the protection device physically breaks said conductive ink, resulting in an open circuit.

13. An alarm system according to claim 12, wherein said mask and ink are laid over a fuse associated with said protection device.

AMENDED CLAIMS

[received by the International Bureau on 22 September 1993 (22.09.93); original claim 1 amended; new claims 2,3,5 and 17 added; claims 2-3 amended and renumbered as claims 4 and 6-16; other claims unchanged (3 pages)]

1. A protection system for power distribution lines comprising at least two stacks of metal oxide varistors, the stacks being arranged in parallel and the varistors of each stack being arranged in parallel such that failure due to deterioration or overstress of a stack or a varistor within one of said stacks will cause disconnection of the failed stack or varistor without operation of a series line fuse.

2. A system according to claim 1 wherein each of the varistors is individually fused.

3. A system according to claim 1 wherein each of the stacks is individually fused.

4. A system according to claim 1, wherein each of said stacks has a stack fuse or an individual component fuse which has an impulse current rating in excess of a line fuse but operates at a lower level to power frequency currents.

5. A system according to any one of the preceding claims in which failure of a stack or varistor is indicated by breakage of an insulated conductive ink connection.

6. In a fuse arrangement for a distribution line protection system, a fuse element comprising a wide, thin strip of copper having low resistance to high frequency current, said strip being encapsulated in flameproof material, such that it will carry an impulse current equivalent to a conventional cylindrical fuse of from two to three times the cross–sectional area of copper, thus permitting disconnection as defined in claim 1, of stacks or varistors within stacks, while maintaining overvoltage protection integrity for impulse levels which may be in excess of the capacity of a line fuse.

7. In a protection system for distribution lines, in which at least two parallel stacks of metal oxide varistors are provided, a monitoring arrangement which monitors the integrity of stack fuses and/or individual metal oxide varistor fuses, and displays the status thereof n a progressively reducing bar graph, irrespective of the order of failure of stacks or varistors within said stacks.

8. A monitoring arrangement according to claim 7, wherein said bar graph is constituted by LEDs.

9. In a protection system for power distribution lines, the provision of clean contacts for transmission of a status alarm to a remote point upon the failure of a predetermined number of internal or individual fuses forming part of said protection system.

10. A protection system for distribution lines, in which a multiplicity of paths for transient currents is provided, said paths leading to overvoltage clamping devices which receive a lower 'per device' current, and produce a lower clamping voltage due to a reduced dI/dt in each conductor.

11. A system according to claim 10, wherein said devices are MOVs and in which the paths are provided by arranging the MOVs in parallel and in parallel stacks.

12. A lightning protection arrangement for electricity distribution lines, including a plurality of groups of protection devices, each of said protection devices being a metal oxide varistor (MOV), each of said groups of protection devices including a plurality of protection devices arranged in parallel, each of said groups being located in parallel, said arrangement operating such that upon failure of a protection device in one of said groups, reduced protection will be provided by the remaining group or groups in the arrangement.

13. An arrangement according to claim 12, wherein said groups are located between and connected to, two conductive plates, one of said conductive plates being connected to the line to be protected, and each connection between one of said groups and a plate is provided with an internal fuse or circuit breaker.

14. An arrangement according to claim 12 or claim 13, further including a lamp or audible alarm which is adapted to operate when a group fails due to the failure of a protection device in that group.

15. An alarm system for indicating the failure of a protection device for electricity distribution lines, including an insulating mask applied to an area in the vicinity of said protection device, and a conductive ink laid over said mask, said ink being connected into an alarm system, such that failure of the protection device physically breaks said conductive ink, resulting in an open circuit.

16. An alarm system according to claim 15 wherein said protection device comprises at least one varistor and a fuse associated with said at least one varistor and said mask and ink are laid over said fuse such that failure of said fuse physically breaks said conductive ink.

17. An alarm system according to claim 15 wherein said protection device comprises at least one stack of varistors and a fuse associated with said stack of varistors and said mask and ink are laid over said fuse such that failure of said fuse physically breaks said conductive ink.

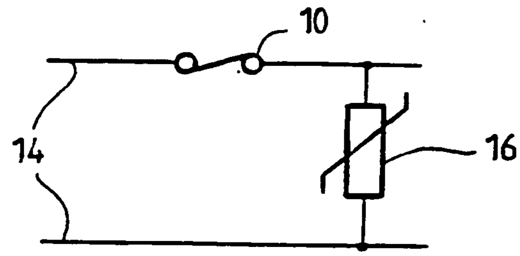


FIG. 1.

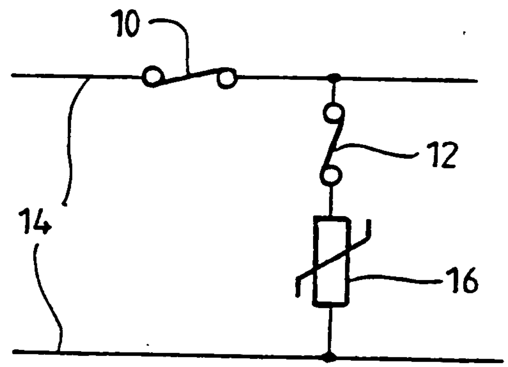


FIG. 2.

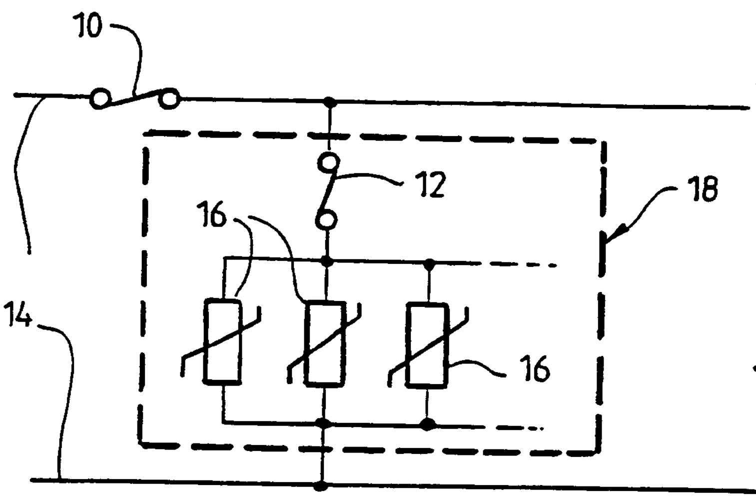


FIG. 3.

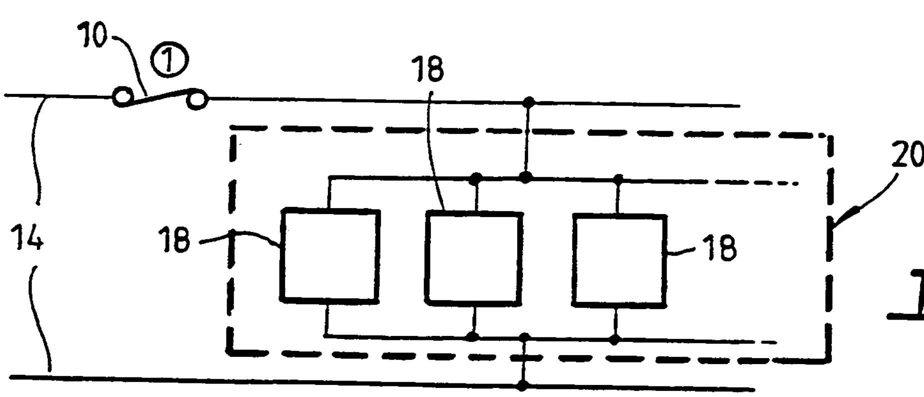


FIG. 4.

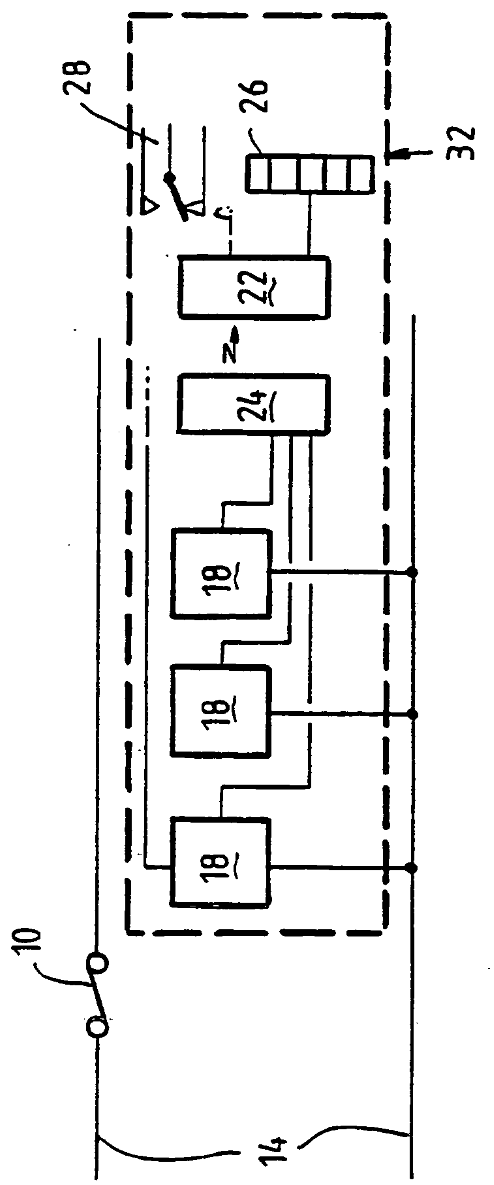


Fig. 5.

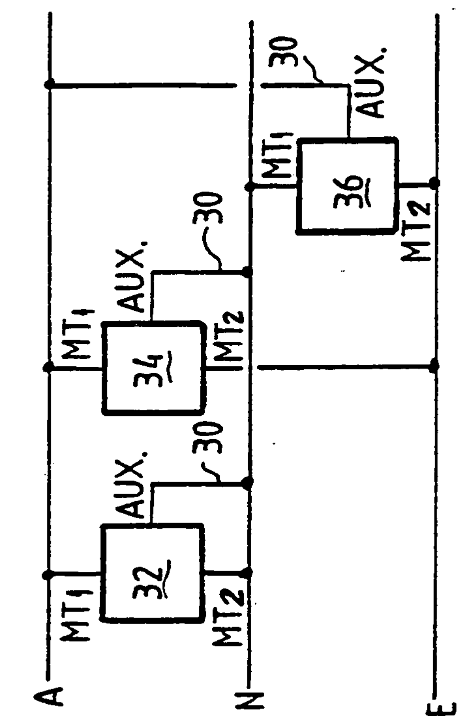


Fig. 7.

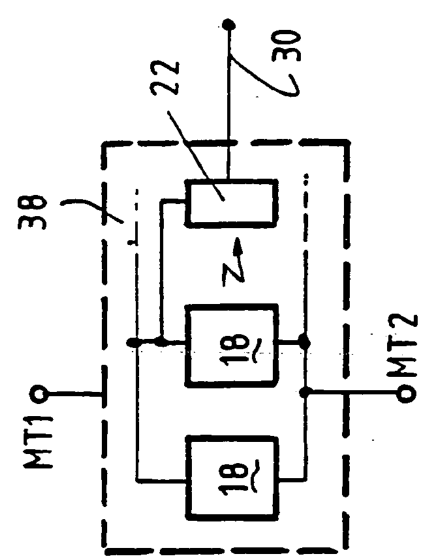


Fig. 6.

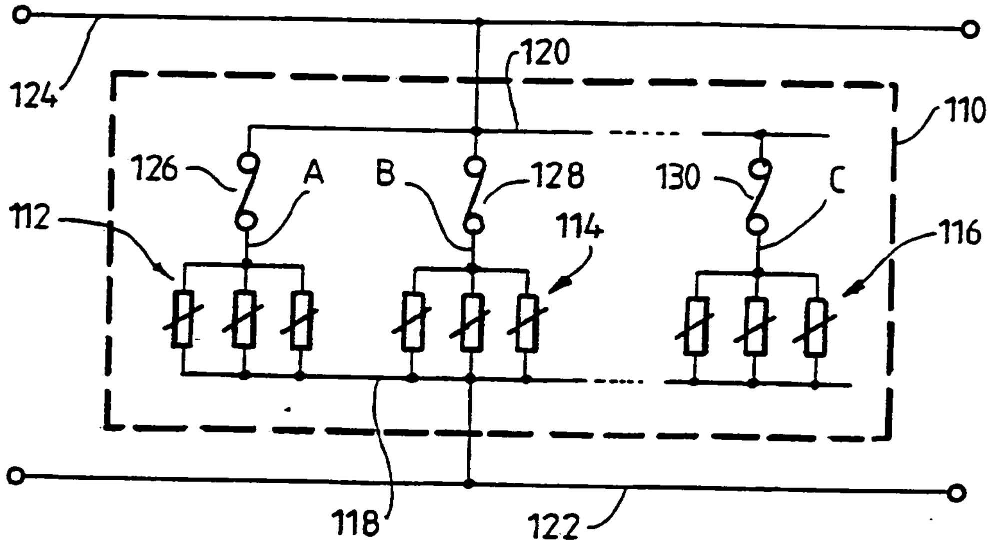


FIG. 8.

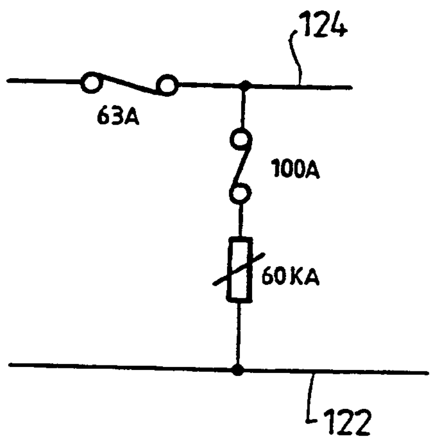


FIG. 9.

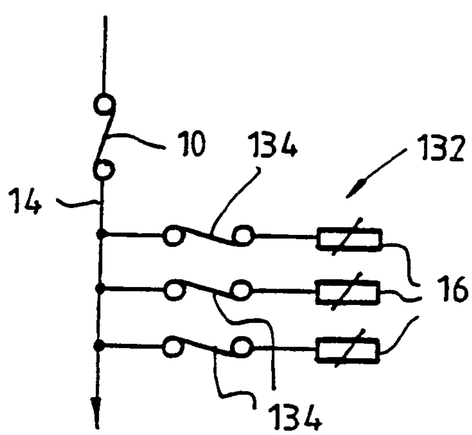


FIG. 10.

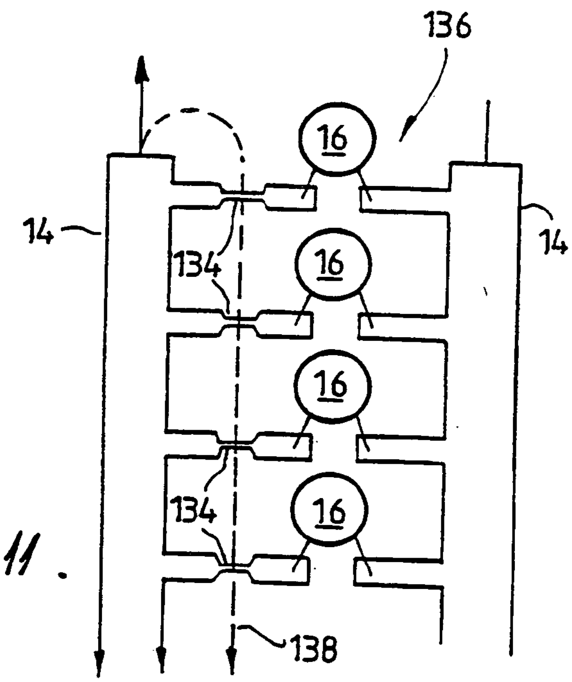


FIG. 11.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU93/00163

**A. CLASSIFICATION OF SUBJECT MATTER**

Int. Cl.[5] H02H 9/04, 3/05, 3/04, H01C 7/12

According to International Patent Classification (IPC) r to both national classificati n and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC H02H 3/04, 3/05, 3/20, 3/22, 9/04, H01C 7/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU : IPC as above

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)
DERWENT, CAPRI, INPADOC

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to Claim No. |
|---|---|---|
| | AU,A, 23520/92 (ASEA BROWN BOVERI AB) 18 March 1993 (18.03.93) | |
| X,P | abstract, Fig. 1 | 6-10 |
| Y,P | abstract, Fig. 1 | 1,11 |
| | AU,A, 15065/92 (H.LP.M. INDUSTRIES PTY LIMITED) 26 November 1992 (26.11.92) | |
| Y,P | abstract | 1,11-13 |
| | US,A, 5023746 (EPSTEIN) 11 June 1991 (11.06.91) | |
| X | abstract, Fig. 1 | 6-10 |
| Y | abstract, Fig. 1 | 1,11 |

[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand th principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cann t be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 14 July 1993 (14.07.93) | 22 JULY 1993 (22.07.93) |

| Name and mailing address f the ISA/AU | Authorized officer |
|---|---|
| AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION<br>PO BOX 200<br>WODEN ACT 2606<br>AUSTRALIA | R. CHIA |
| Facsimile No. 06 2853929 | Telephone No. (06) 2832185 |

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation f document, with indication, where appropriate f the relevant passages | Relevant to Claim No. |
|---|---|---|
| | US,A, 4907119 (ALLINA) 6 March 1990 (06.03.90) | |
| X | abstract, column 5 lines 53-59 | 6-11 |
| Y | abstract, claim 1 | 1,12,13 |
| | Patent Abstracts of Japan, E-1062, page 41, JP,A, 3-36923 (HITACHI LTD) 18 February 1991 (18.02.91) | |
| X | abstract | 6-10 |
| Y | abstract | 1 |
| | Derwent Abstract Accession No. 86-23077/35, Class X12, J 61-161702 (TOSHIBA KK) 22 July 1986 (22.07.86) | |
| X | abstract | 6-10 |
| Y | abstract | 1 |
| | Derwent Abstract Accession No. 83-720101/30, Class V01, J 58-103103 (MITSUBISHI ELECTRIC CORP) 20 June 1983 (20.06.83) | |
| X | abstract | 6-10 |
| Y | abstract | 1 |
| | WO,A, 90/16103 (SQUARE D COMPANY) 27 December 1990 (27.12.90) | |
| Y | abstract, Fig. 3 | 4,5 |
| | US,A, 2930961 (LEZAN) 29 March 1960 (29.03.60) | |
| Y | claim 1, Fig. 1 | 4,5 |
| | Patent Abstracts of Japan, E-164, page 154, JP,A, 54-144946 (TOKYO SHIBAURA DENKI K.K.) 11 December 1979 (11.12.79) | |
| A | abstract | |
| | EP,A, 382447 (BOWTHORPE INDUSTRIES LIMITED) 16 August 1990 (16.12.90) | |
| A | abstract, Fig. 2 | |

**Box I** **Observations where certain claims were found unsearchable (Continuation of Item 1 f first sheet)**

This international search report has not established in respect f certain claims under Article 17(2)(a) for th following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box II** **Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

The international application does not comply with the requirement of unity or invention because it does not relate to one invention or group of inventions so linked as to form a single general inventive concept. In coming to this conclusion the International Search Authority has found that there are four inventions:

1. Claims 1,2,4,5,7-11 define a protection system for distribution lines with a multiplicity of paths leading to overvoltage clamping devices, in particular metal oxide varistors in parallel.
2. Claim 3 defines a fuse arrangement for a distibution line protection system wherein the fuse element comprises a wide, thin strip of copper being encapsulated in flameproof material.
3. Claim 6 defines a protection system for distribution lines with provision of clean contacts for transmission of a status alarm to a remote point.
4. Claims 12,13 define an alarm system for indicating the failure of a protection device for electricity distribution lines comprising an insulating mask over the device and a conductive ink laid over the mask.

Since the abovementioned groups of claims do not share the technical features identified, a "technical relationship" between the inventions as defined in PCT Rule 13.2 does not exist. Accordingly, the international application does not relate to one invention or to a single inventive concept. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of additional fees.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims
2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark n Protest**

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment f additional search fees.

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

| Patent Document Cited in Search Report | | Patent Family Member | | | | | |
|---|---|---|---|---|---|---|---|
| AU | 23520/92 | SE | 9102694 | CA | 2078271 | EP | 537486 |
| US | 4907119 | US | 4866560 | US | 4931895 | US | 5130884 |
| | | US | 5148345 | US | 4901187 | US | 5006950 |
| | | US | 5140491 | | | | |
| WO | 90/16103 | CA | 2059668 | EP | 477250 | US | 5010438 |
| EP | 382447 | AU | 49196/90 | CA | 2009424 | GB | 2230661 |
| | | ZA | 9000899 | JP | 2271501 | NO | 900558 |
| | | US | 5218508 | | | | |

END OF ANNEX